PROSPECTS OF CAPTIVE BREEDING FOR THREATENED AUSTRALIAN NON-MARINE INVERTEBRATES

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Apparent success of captive breeding in conservation of threatened vertebrates suggests that it is also an option for threatened invertebrates. Captive breeding is misunderstood, including its use in conservation and commercial programmes and the distinction between maintenance and breeding in captivity. It is not a panacea for conservation of threatened invertebrates but part of a recovery plan of threatened species. Uncontrolled attempts at captive breeding and subsequent release into the wild should be prevented. Hence, a protocol for captive breeding of threatened non-marine Australian invertebrates is proposed. ☐*Captive breeding, invertebrate conservation, Australia.*

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Wildlife conservation can be in situ and/or ex situ. Captive breeding of vertebrates dominates the latter. It forms a major and often successful component of recovery plans for threatened species of vertebrates (Cohn, 1988).

Captive breeding is controversial because of the high costs of saving few species. Its critics argue that funds would be better spent saving species in their natural habitats. It should not be seen as a solution to save all threatened species but should be used in 'flagship' programmes to highlight threats both to animals and their habitats.

Its 'success' in vertebrates suggests its value with threatened invertebrates whose generally high rates of immature mortality can be reduced by the method. These assumptions are examined for captive breeding of threatened Australian non-marine invertebrates and if it becomes an integral part of their conservation strategies, issues need to be resolved.

SCOPE

The importance of captive breeding in vertebrate conservation is recognised by the IUCN, which has a Species Survival Commission Captive Breeding Specialist Group (SSC-CBSG). In 1987, the IUCN released a policy statement that the survival of many species, especially those in much reduced and fragmented habitats, requires establishment of self-sustaining captive populations and other supportive intervention (IUCN SSC-CBSG, 1987).

The SSC-CBSG has focused on vertebrates but, in 1990, an Invertebrate Group was formed, finally heeding earlier pleas (Morton, 1983). Objectives of this Group include:

1. Communication within regions of groups involved in invertebrate captive management and conservation, with other SSC Invertebrate Specialist Groups and with other relevant organisations;
2. Education to promote invertebrate conservation and roles of live invertebrates in exhibitions and use of invertebrates in education;
3. Research into captive breeding technology; and
4. Conservation of invertebrates, promotion of habitat protection and in situ conservation (Hughes & Bennett, 1991).

Captive breeding consists of the breeding programme and end-use of captive bred material. The term is associated with breeding threatened species for conservation. Other activities that need captive breeding are overlooked. Its aims are:

1. Conservation of threatened species;
2. Scientific research; (a), life history studies and (b), Biomonitoring agents;
3. Commerce: (a), Specimens for invertebrate zoos; (b), trade of live and dead specimens for collectors; (c), specimens for teaching purposes; (d), invertebrate cultures as vertebrate food; (e), commercial production—aquaculture, silk, etc., and (f), breeding of biological control agents.

Commercial ventures, especially 3(d) - 3(f), are generally run on a larger scale. Maintaining specimens and breeding them in captivity are different. Maintenance is removal of specimens from the wild and their display with no serious attempt to breed them. Captive breeding is the initial removal of specimens from the wild and rearing in captivity.

PROSPECTS FOR CAPTIVE BREEDING OF THREATENED AUSTRALIAN INVERTEBRATES

Of 269 programmes officially recognised by the American Association of Zoological Parks and Aquariums, only one involves an invertebrate (Hughes & Bennett, 1991). This is international programme maintains species of *Partula* snails, now extinct in the wild, for possible release back into Polynesia when conditions are suitable (Tonge & Bloxam, 1991). Other programmes include the Red-kneed tarantula, *Euathlus smithii*, although there has been no attempt at re-introduction (Clarke, 1991); the Italian ground beetle, *Chrysocarabus olympiae*, for which the success of re-introduction is still unclear (Malausa & Drescher, 1991); and many attempts for species of British butterflies (Thomas, 1989). However, there is still very little co-ordination, at either the regional or international level, of captive breeding of species already kept in culture (Hughes & Bennett, 1991).

No captive bred threatened Australian invertebrates are known. Several species have been considered and an initial management plan for the Eltham Copper butterfly, *Paralucia pyrodiscus lucida* (Vaughan, 1988) has been proposed.

Feasibility of captive breeding for threatened Australian invertebrates is examined using the list of Hill & Michaelis (1988) as an exercise. However, those taxa are here placed into broad habitat groups and trophic levels (Table 1). The habitat categories are very broad and artificial but, in terms of captive breeding, over 25% of the taxa have habitat requirements that may be technically difficult to simulate in an ex situ situation (namely aquatic habitats and caves). Some species may have aquatic immature stages and adults that disperse and mate in terrestrial habitats. Although artificial streams and simulated cave environments are achievable in the laboratory, there is still a gap between maintenance and breeding. At the trophic level, the breakdown is given in Table 1. Theoretically, predators and herbivores should be easier to breed unless they have some special habitat requirements, specialised dietary requirements or have some biotic interactions with other species. For example, over half of the herbivores are butterflies, and this suggests that the only issue is the host plant requirements of the herbivore. However, many of these herbivores are intimately associated with ants. This adds another dimension to captive breeding . For other species, such as the ant *Nothomyrmecia*, sociality may be a barrier to successful captive breeding.

Table 1. Number of species or subspecies of threatened invertebrates grouped by their 'habitat' and 'trophci level' requirements (from Hill & Michaelis, 1988)

'TROPHIC LEVEL'	'HABITAT'				
	aquatic	cave	ground	vegetation	%
Predator	7	1	9		20.2
Herbivore				48	57.2
Scavenger	1	4		2	8.3
Omnivore	8	2		1	13.1
Parasitoid				1	1.2
%	19.1	8.3	10.7	61.9	

Some technical issues associated with proposed captive breeding programmes follow. In 1992, the Victorian Department of Conservation and Natural Resources suggested that fuel reduction burning was needed to maintain the habitat of the Eltham Copper Butterfly and that butterflies should be collected and bred in captivity in case the burn adversely affected their populations. The Melbourne Zoo Butterfly House was nominated. However, the captive breeding programme has been temporarily suspended because of (1) uncertainty about breeding the dwarf form of the *Bursaria spinosa* host plant of the Eltham Copper butterfly; (2) lack of data on maintaining the *Notoncus* ants associated with it; (3) question of where and how much source material could be collected; (4) lack of information about the butterfly's genetics; and (5) the Butterfly House was set up for tropical butterflies not for temperate species, like the Eltham Copper.

Captive breeding was also a suggested conservation option for the Giant Gippsland Earthworm, *Megascolides australis*. However, much early biological data on *M.australis* were incorrect (Van Praagh et al., 1989) and its slow developmental rate, apparent longevity (Van Praagh, 1992), and its reliance on an intact permanent three-dimensional burrow system (Kretzschmar & Aries, 1992) make it difficult to be captive bred.

Few species listed in Hill & Michaelis (1988) could be successfully captive breed. Biological data for many are not known and habitat requirements may be difficult to simulate in the laboratory. Issues arising from any captive breeding proposal for threatened invertebrates could be resolved more easily if a protocol for captive breeding is developed and accepted (Lees, 1989).

Such a protocol should not be used in isolation but has to be closely linked with protocols for translocation and reintroduction. These protocols prevent events like that in the United Kingdom where an estimated 1,000 or more reintroductions of butterflies have been attempted. In some attempts, wild stock was translocated while in others captive bred stock were released. These attempts were poorly documented and in the past there was little control over the efforts (Thomas, 1989). This must not occur in Australia where most invertebrates are poorly documented and uncontrolled introductions may have unforseen ecological consequences. Translocation of captive bred freshwater crayfish already occurs (Horwitz, 1990).

PROTOCOL

For threatened species, a recovery plan that incorporates all possible conservation strategies is needed. The primary aim of any recovery plan should be the protection of species in their original habitat through the control of threatening processes. Captive breeding should only be considered as part of an overall recovery plan and as the last option when the species cannot survive in its original habitat or as a means of obtaining basic biological information required to implement a recovery plan. If it is to be considered, then two primary issues need to be assessed: potential for its success and for reintroduction success. Reintroduction is a major undertaking in itself and will not be considered further here because it requires its own protocol (New, in press).

Such a protocol could also include a priority scoring system that weights each technical issue with a score (1 = known, no adverse effects, or possible; 0 = not known, some adverse effects, or not possible). The sum of those scores may indicate the feasibility of captive breeding of any particular taxon.

1. What will be captive bred? Is the proposed taxon a species or subspecies?
2. What will happen to captive bred specimens? Will they be reintroduced into an already occupied habitat or into a former one? What effects will reintroduction have on other taxa? What life history stage should be used for reintroduction? Is introduction to a new habitat the only option? Is there any commercial potential for captive bred material?
3. Biology. Is there adequate knowledge of the taxon's biology — life history stages, developmental periods, longevity, feeding habits, habitat requirements and breeding behaviour? Do immature and adult habitats differ? Is the taxon social? Does the taxon have any special associations or interactions with plants, ants or otherwise?
4. Distribution. How well known is the taxon's distribution? Has its distribution been adequately surveyed? Are all populations known for consideration as potential sources of breeding stock?
5. Genetics. This is a very difficult area because genetic data of most invertebrates are unknown. Is there information on the taxon's intraspecific genetic variation (Morton, 1991b)? What measures can prevent possible inbreeding depression, minimise genetic adaptation to captivity and make the captive environment like the wild? This latter aspect may conflict with other technical aspects that improve the success of captive breeding programmes, e.g. use of artificial diets, controlled environments to maximise breeding success, and exclusion of natural enemies.
6. What is the source population and what effect will removal have on the taxon's survival?
7. If material of a taxon in decline is to be removed from the wild, when should this occur in relation to that trend?
8. Is there sufficient technical knowledge for successful breeding of the taxon in captivity?
9. Are there adequate facilities for captive breeding? This requires adequate infrastructure support for successful rearing, e.g., controlled rearing rooms, greenhouse facilities and staff. Are the facilities suitable? For example, calls for captive breeding of butterflies in the United Kingdom revolve around using facilities of many butterfly farms (Lees, 1989). Are quarantine procedures adequate to prevent introduction of diseases or unwanted species of invertebrates? What are the consequences of captive bred specimens escaping and breeding in the wild? Are measures adequate for the control of bacterial, fungal, protozoan and viral infection (Rivers, 1990)?
10. What are the potential and real benefits for other threatened taxa?

DISCUSSION

At this stage, prospects of captive breeding of threatened Australian invertebrates may appear to be low but its potential role in invertebrate conservation should not be underestimated because:

1. Some species may need captive breeding;
2. Captive bred flagship species could be used effectively to highlight the need for invertebrate (and habitat) conservation;
3. It is an important source of biological data that are essential for threatened species conservation (Lees, 1989); and
4. Captive breeding technology provides benefits like advances in equipment and techniques (Morton, 1991a), including research into the use of artificial

diets and in mass culturing technology required for aquaculture, production of biological control agents, etc.

Many invertebrate species can be maintained and bred in a relatively small space. Their true biological diversity could be displayed – a major advantage over vertebrates

Many potential 'cute and chitinous' invertebrates can be used as flagship taxa for the group's conservation. However, we are failing in our duty to that issue if we do not fully use their diversity as part of a broad, integrated conservation agenda that involves a public awareness educational programme, live exhibits, encouraging the use of local natural history to stimulate interest in conservation (Yen, 1993) and captive breeding of selected threatened invertebrates. It will be impossible to apply single species conservation strategies to most invertebrate species. A broader agenda will be more useful to conserve most invertebrate species because it has greater potential to convey their need for conservation. Captive breeding of selected flagship taxa could be a powerful part of this agenda. To this end, a protocol for captive breeding of threatened invertebrates is a small but important step.

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